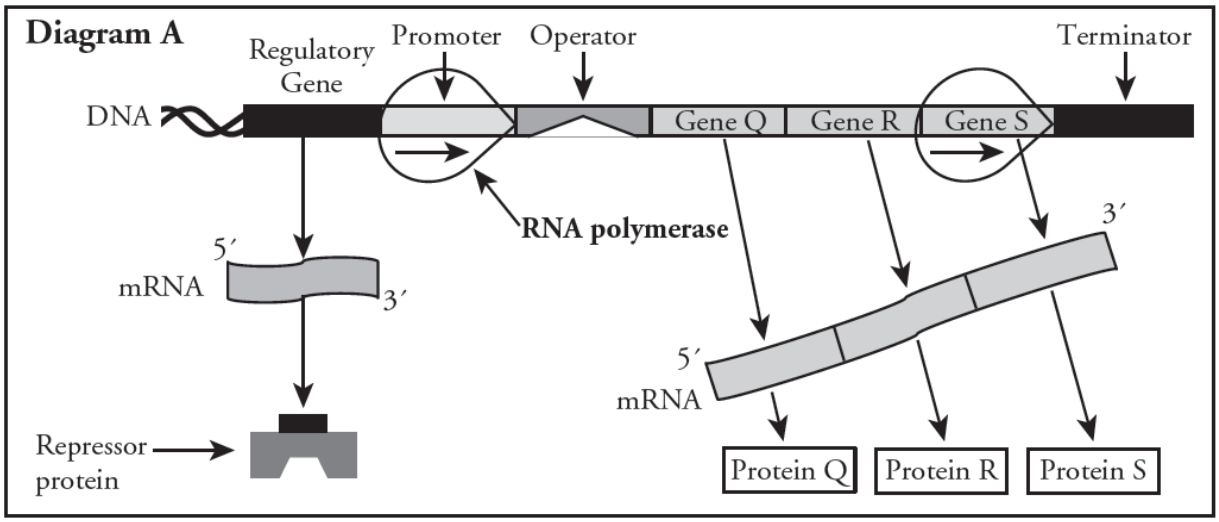
Name _____

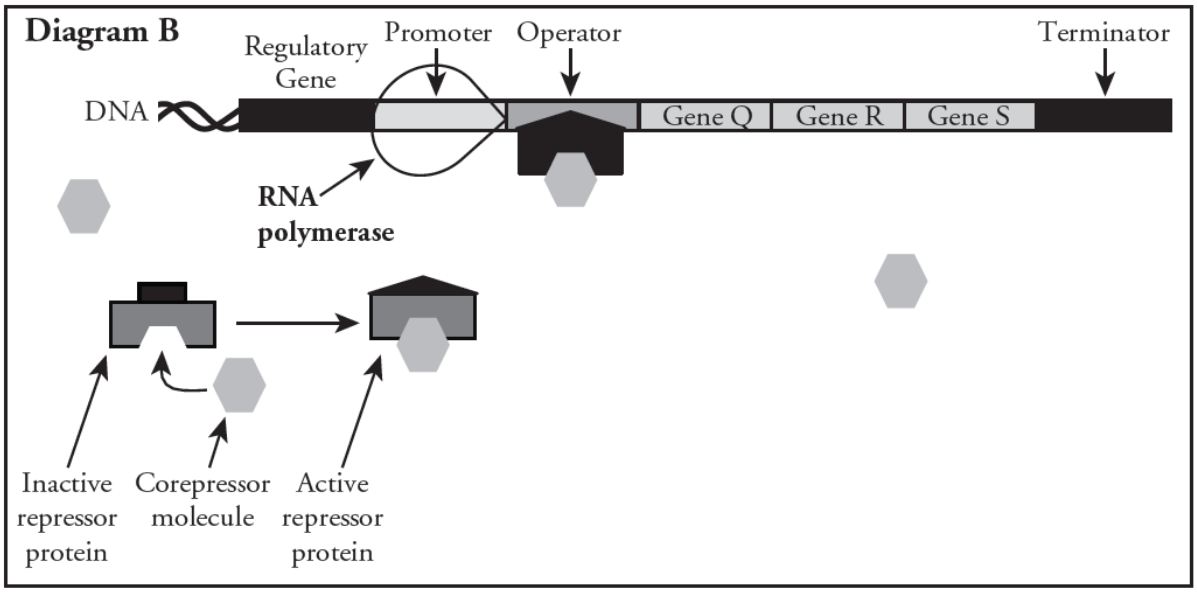
Control of Gene Expression in Prokaryotes

Introduction:

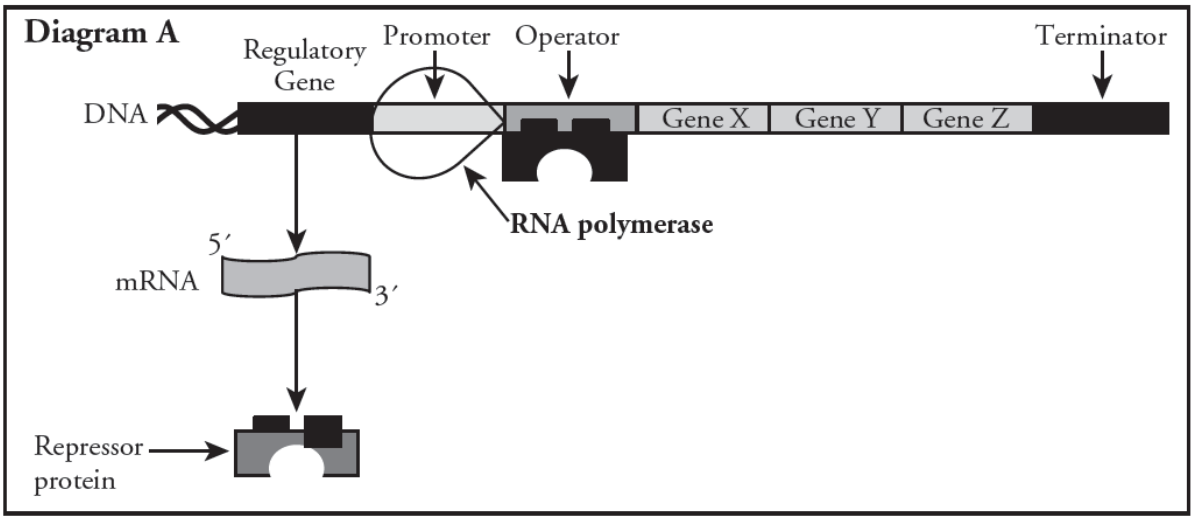
Houses usually have a light source in every room, but it would be a waste of energy to leave every light on all the time, so there are switches to turn off the lights in rooms that are not in use. Sometimes one switch controls several lights in the same room. Likewise, prokaryotic cells can turn genes on and off based on environmental factors. Sometimes related genes are grouped together with one switch. This group of genes, along with the sections of DNA that regulate them, is called an **operon**.

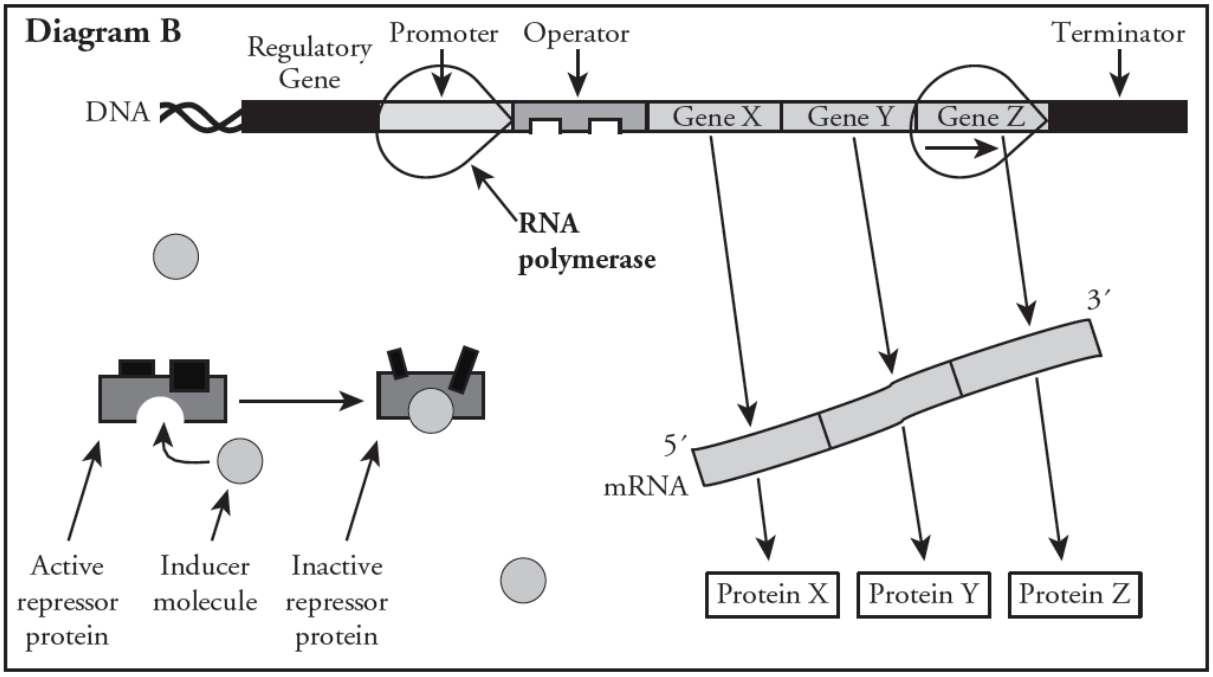
A Repressible Operon





An Inducible Operon





Procedure:

In this activity, you and your partner will investigate the parts of an operon and simulate the role of repressors in turning the transcription of genes on and off.

Model I: The Parts of an Operon (Yellow)

1. Starting on the left, move your bead along the string at the top of the yellow operon. Pay careful attention to where it starts, stops, and what it passes along the way.
2. "Reset" your operon with the bead on the left and then place the binder clip in the operator region of the operon. Once again, move your bead along the string, paying careful attention to where it starts and stops.
3. Answer the questions under Model I of the analysis section.

Model II: A Repressible Operon (Green)

4. Using the green operon, slide the bead as far left as possible on the string.
5. Locate your binder clip with the marble attached as well as your white pom-pom.
6. Try to attach the binder clip with the marble to the operator region of the operon. Note what happens.
7. Once again, move your bead along the string, paying careful attention to where it starts and stops.
8. Now replace the marble with the white pom-pom.
9. Again, try to attach the binder clip (now with the white pom-pom attached) to the operator region of the operon. Note what happens.
10. Once again, move your bead along the string, paying careful attention to where it starts and stops.
11. Answer the questions under Model II of the analysis section.

Model III: An Inducible Operon (Red)

12. Using the red operon, slide the bead as far left as possible on the string.
13. Locate your other binder clip (without any rubber band, marble, or pom-pom) and tan pipe-cleaner.
14. Now place the binder clip in the operator region of the operon. Once again, move your bead along the string, noting where it starts and stops.
15. Next, thread your pipe-cleaner through the openings in the silver prongs of the binder clip and secure it by squeezing the prongs together as much as possible and tightly twisting the pipe-cleaner around itself.
16. Again, try to attach the binder clip (now with the pipe-cleaner attached) to the operator region of the operon. Note what happens.
17. Once again, move your bead along the string, paying careful attention to where it starts and stops.
18. Answer the questions under Model III of the analysis section.
19. Complete your conclusion using complete sentences.

Analysis:
Use the diagrams found in the introduction as well as your model operon to answer the following questions.

Model I: The Parts of an Operon

1. Explain what each of the following represents:
   - Bead _____
   - Binder clip _____

2. Where on the DNA strand does RNA polymerase bind to start transcription?

3. Other than the gene that regulates the operon, how many genes are located within the operon?

4. Where on the DNA strand does transcription end?

5. Where on the DNA strand does the repressor bind?

6. What happened to the transcription of the genes when the repressor was bound to the operon?

7. Which part of the operon acts as an on/off switch?

Model II: A Repressible Operon

8. Explain what each of the following represents:
   - Binder clip with marble attached _____
   - White pom-pom _____

9. What happened when you tried to attach the binder clip with the marble to the operator region of the operon?

10. How did this affect transcription of the genes within the operon?

11. What happened when you tried to attach the binder clip (now with the white pom-pom attached) to the operator region of the operon?

12. How did this affect transcription of the genes within the operon?

13. In this model, did you turn transcription on or off?

<u>Model III: An Inducible Operon</u>

14. Explain what the following represents:

- Pipe-cleaner _____

15. What happened to the transcription of the genes when the repressor was bound to the operon?

16. What happened when you attached the pipe-cleaner to the binder clip?

17. How did this affect transcription of the genes within the operon?

18. In this model, did you turn transcription on or off?

Conclusion:

Use your diagrams, model operons, and answers to your analysis questions to help you write your conclusion in the space below**. Use complete sentences** to summarize what you learned about repressible and inducible operons. Be sure to use science vocabulary in your explanation (ie-don't just talk about beads and binder clips but explain what they have to do with operons). Be sure to EXPLAIN the following:

- What happens to the transcription of genes within an operon if an active repressor is present?
- Is a repressible operon usually on or off?
- What is the role of the corepressor?
- Is an inducible operon usually on or off?
- What is the role of the inducer?

Applications:

Use your notes, along with what you have learned from this activity, to answer the remaining questions.

1. Is the *trp* operon an example of a repressible or inducible operon?

2. Is the *trp* operon normally on or off?

3. What compound typically serves as the corepressor of the *trp* operon?

4. Explain what would happen within the trp operon in each of the following scenarios. Include what happens to the repressor, whether or not transcription occurs, and whether or not tryptophan will be synthesized.

a. If tryptophan levels are low

b. If tryptophan levels are high

5. Is the *lac* operon an example of a repressible or inducible operon?

6. Is the *lac* operon normally on or off?

7. What compound typically serves as the inducer of the *lac* operon?

8. Explain what would happen within the lac operon in each of the following scenarios. Include what happens to the repressor, whether or not transcription occurs, and whether or not lactose will be hydrolyzed.

a. If lactose levels are low

b. If lactose levels are high

9. Which type of operon, an inducible or repressible one, would an organism like use to produce enzymes and other proteins required to break down a nutrient in its environment? Justify your answer with specific details from Model II or III.

10. Which type of operon, an inducible or repressible one, would an organism like use to produce enzymes and other proteins required for the cell to manufacture a molecule needed from smaller molecules in its environment? Justify your answer with specific details from Model II or III.

11. Propose an explanation for why operons evolved in prokaryotes. What advantage do organisms have when they group genes together with a regulatory system?